AP Physics Fall 2013
Test 12

Name: Key

Short Answer	____________	30 pts
Problem 10	____________	13 pts
Problem 11	____________	7 pts
Problem 12	____________	14pts
Problem 13	____________	8pts
Problem 14	____________	28pts
Bonus	____________	18 pts
Total	____________	

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6 pts **1.** State the two conditions (either in words or equations) that must be met for a rigid body to be in equilibrium

The sum of the forces is zero. (+3)

The sum of the torques is zero. (+3)

or

$\sum \vec{\tau} = 0$ $\sum \vec{F} = 0$

3 pts **2** State the definition of pressure (either in words or equation)

Pressure is the force divided by area.

or

$$P = \frac{F}{A}$$

3 pts **3.** State the definition of density (either in words or equation)

Density is mass divided by volume.

or

$$\rho = \frac{M}{V}$$

3 pts **4.** State Pascal's Principle in words.

A change in pressure applied to an enclosed fluid is transmitted undiminished to every point in the fluid and to the walls of the container.

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3 pts **5.** State Archimedes' Principle in words.

Any object partially or fully submerged in a fluid experiences an upward buoyant force whose magnitude is equal to the weight of the displaced fluid.

3 pts **6.** State Pascal's Law (either in words or equation)

The pressure in a fluid increases with depth by a term equal to the product of the density of the fluid, acceleration of gravity, and the depth.

or

$$\boxed{P = P_0 + \rho g h} \quad \text{or} \quad \Delta P = \rho g h$$

3pts **7.** Explain why a person can lie on a bed made up of hundreds of sharp nails and be unharmed, but the same person will have their foot puncture if they step on a single sharp nail.

Many nails increases the area thereby reducing the pressure to a safe level.

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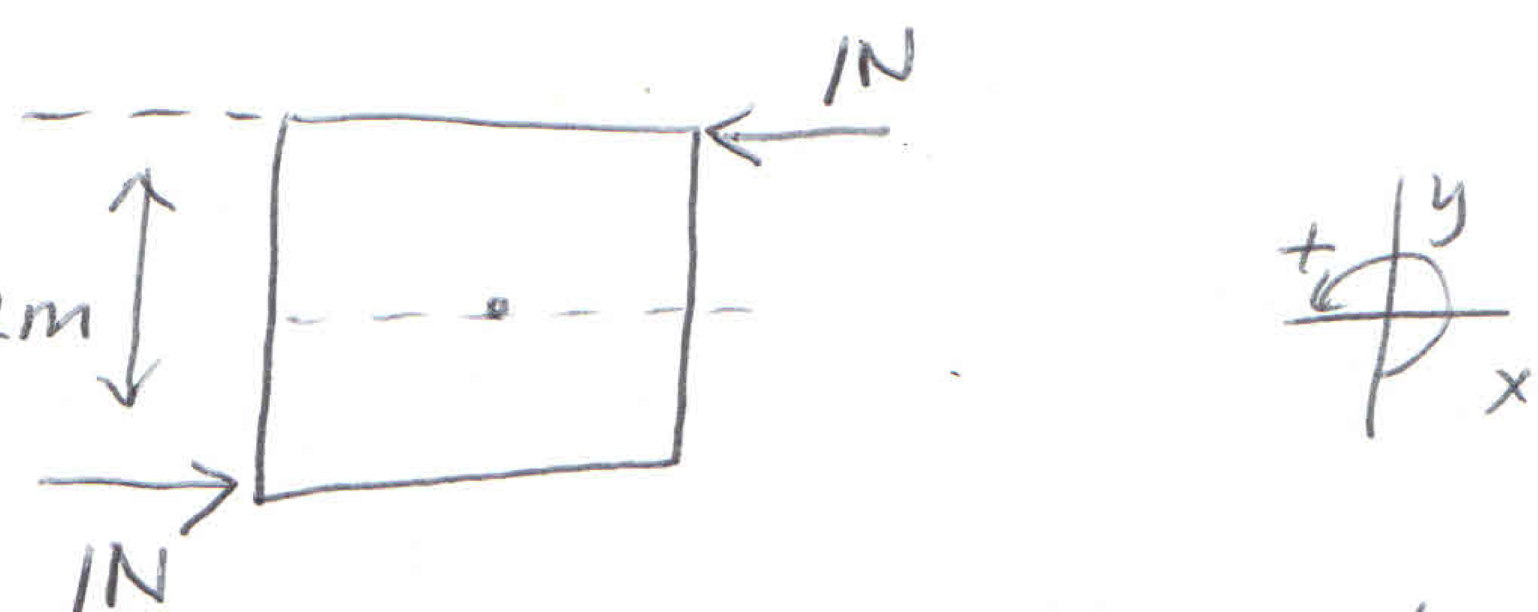
3 pts **8.** A small amount of water is boiled in a 1-gallon metal can. The can is removed from heat and the lid put on. Shortly thereafter the can collapses. Explain how this occurs?

The steam removes air from the can. When the remaining air in the can cools, the pressure inside is reduced compared to the air pressure outside the can. This creates a net inward force that crushes the can.

3 pts **9.** Give an example (be specific including drawing a picture if necessary) where an object is not in equilibrium even though the net force upon the object is zero.



The net force is zero, but there is still a net torque of 2Nm about an axis through the object's center.

Any answer that has No force, but a torque is correct!!

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13 pts **10.** A swimming pool is 10.0 m long and 4.0 m wide. The swimming pool is filled to a depth of 2.0 m.

4 pts **A.** What is the mass of the water?

(+1) $m = \rho V$

$V = (10m)(4m)(2m) = 80m^3$ (+1)

$m = (1000 \frac{kg}{m^3})(80m^3) = \boxed{80{,}000\ kg}$ (+1) # (+1) units

5 pts **B.** What is the absolute pressure at the bottom of the pool?

(+1) $P = P_0 + \rho g h$ "Pascal's Law"

$P = (1.013 \times 10^5 \frac{N}{m^2}) + (1000 \frac{kg}{m^3})(9.8 m/s^2)(2m)$ (+1) (+1)

$P \cong \boxed{1.21 \times 10^5\ Pa}$ (+1) (+1) suitable units (N/m², etc)

4 pts **C.** What is the force on the bottom of the pool?

(+1) $F = PA$ "Definition of Pressure"

$F \cong (1.21 \times 10^5 Pa)(10m)(4m)$ (+1)

$F \cong \boxed{4.84 \times 10^6\ N}$ (+1) (+1) units

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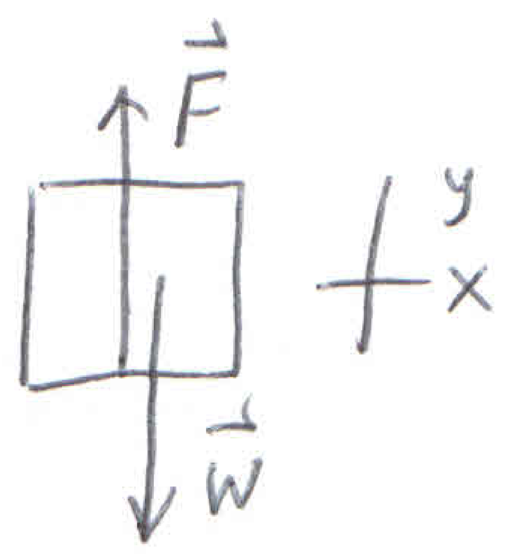
7 pts **11.** The maximum gauge pressure in a hydraulic lift is 17.0 atm. What is the largest vehicle by mass that it can lift if the diameter of the output line is 28.0 cm?

(+1) $F = PA$ "Definition of Pressure"

(+1) $A = \pi\left(\frac{d}{2}\right)^2 = \pi(0.14\,m)^2 \cong 0.0196\pi\,m^2 \cong 0.06158\,m^2$

(+1) $P = (17.0\,atm)\left(\frac{1.013\times10^5\,N/m^2}{1\,atm}\right) \cong 1.722\times10^6\,N/m^2$

$F \cong \left(1.722\times10^6\,\frac{N}{m^2}\right)\left(0.06158\,m^2\right) \cong 1.06\times10^5\,N$ (+1)



$\Sigma F_y = 0 = F - W$

$F = W = mg$

$\Rightarrow m = \frac{F}{g}$ (+1)

$m \cong \frac{1.06\times10^5\,N}{9.8\,m/s^2} \cong$ $\boxed{1.08\times10^4\,kg}$

(+1) # (+1) units

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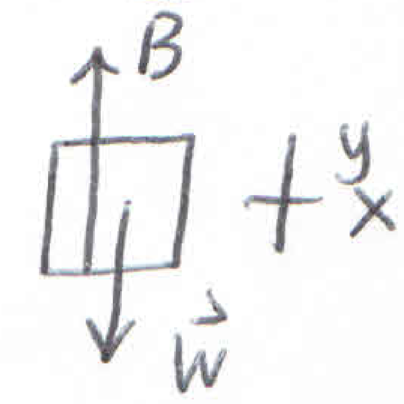
14 pts **12.** A cube with sides of 15 cm in length and a density of 0.65 g/cm³ is floating in a fluid of density 0.85 g/cm³.

6 pts **A.** What is the buoyant force upon the object?

(+1) Floating so B = weight of Object



$\Sigma F_y = 0 = B - W$

$B = mg = \rho_o V_o g$ (+1)

$B = (650 \frac{kg}{m^3})(.15m)^3(9.8 m/s^2)$

(+1) (+1)

$B \cong$ **21.5 N** ← (+1) # ← (+1) units

4 pts **B.** What percent of the object's volume was submerged?

(+1) $\frac{V_s}{V_o} = \frac{\rho_o}{\rho_f}$ "Archimedes' result"

(+1) $\frac{V_s}{V_o} = \frac{0.65 g/cm^3}{0.85 g/cm^3}$

(+1) $\frac{V_s}{V_o} \cong 0.765$

(+1) $\Rightarrow \frac{V_s}{V_o}\% \cong$ **76.5%**

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4 pts **C.** What volume of fluid was displaced by the object?

(+1) $V_s = V_o$ (fraction submerged)

(+1) $V_s \cong (15\,cm)^3 (0.765)$

$V_s \cong \boxed{2.58 \times 10^3\ cm^3} \cong 2.58 \times 10^{-3}\ m^3$

(+1) # (+1) suitable units

or

(+1) $B = \rho_f V_s g$ "Archimedes' Principle"

$$V_s = \frac{B}{\rho_f g}$$

(+1) $$V_s \cong \frac{21.5\,N}{\left(850\,\frac{kg}{m^3}\right)\left(9.8\,m/s^2\right)}$$

$V_s \cong \boxed{2.58 \times 10^{-3}\ m^3}$

(+1) # (+1) units

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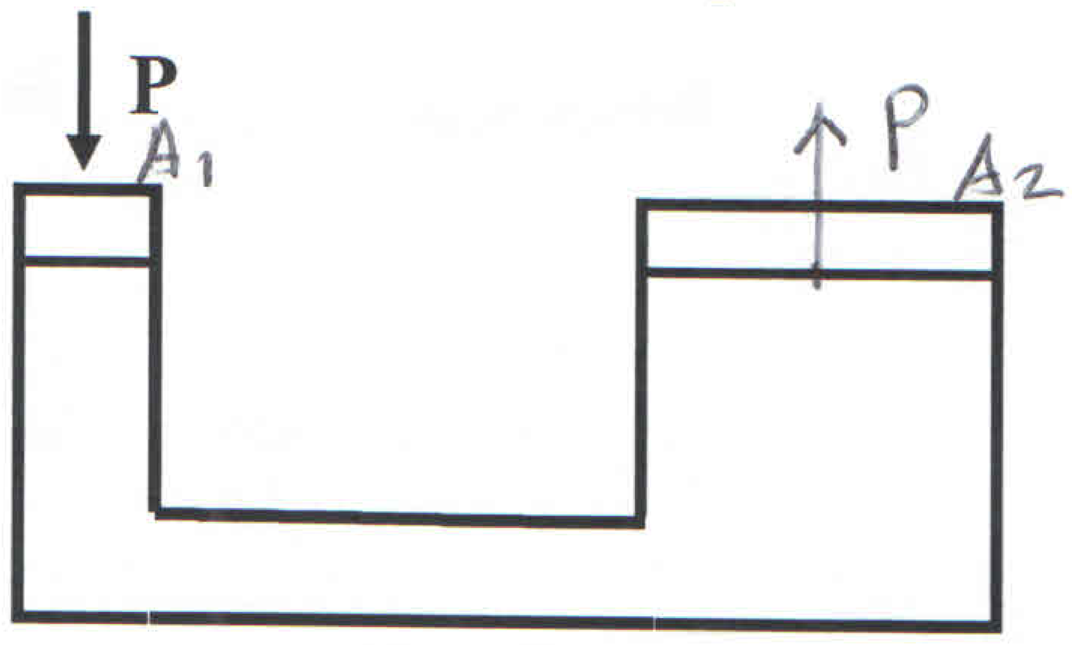
8 pts **13.** A hydraulic jack is shown below. The large piston's cross sectional area is 200 cm^2 and the small piston's cross sectional area is 5 cm^2.



If a pressure of 45,000 Pa is applied to the small piston,

3 pts **A.** what is the pressure at the large piston?

$P = \boxed{4.5\times10^4\ Pa}$ "Pascal's Principle"

5 pts **B.** what is the force on the large piston?

(+2) $F_2 = PA_2$ "Definition of Pressure"

$A_2 = (200\ cm^2)\left(\frac{1m}{100cm}\right)^2 \cong 2.0\times10^{-2}\ m^2$ (+1)

$F_2 = (4.5\times10^4\ \frac{N}{m^2})(2.0\times10^{-2}\ m^2)$

$F_2 = \boxed{900N}$

(+1)# (+1) units

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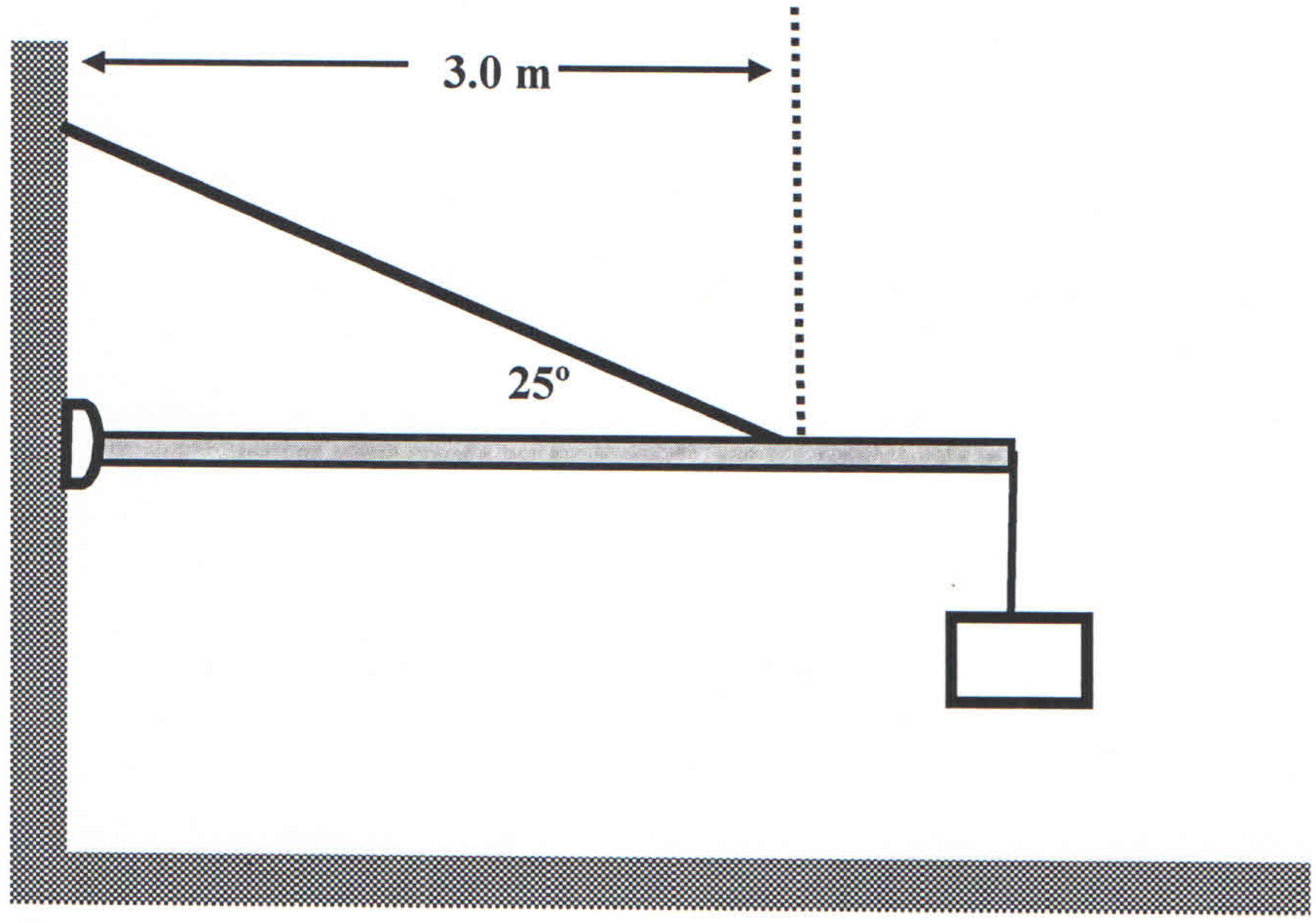
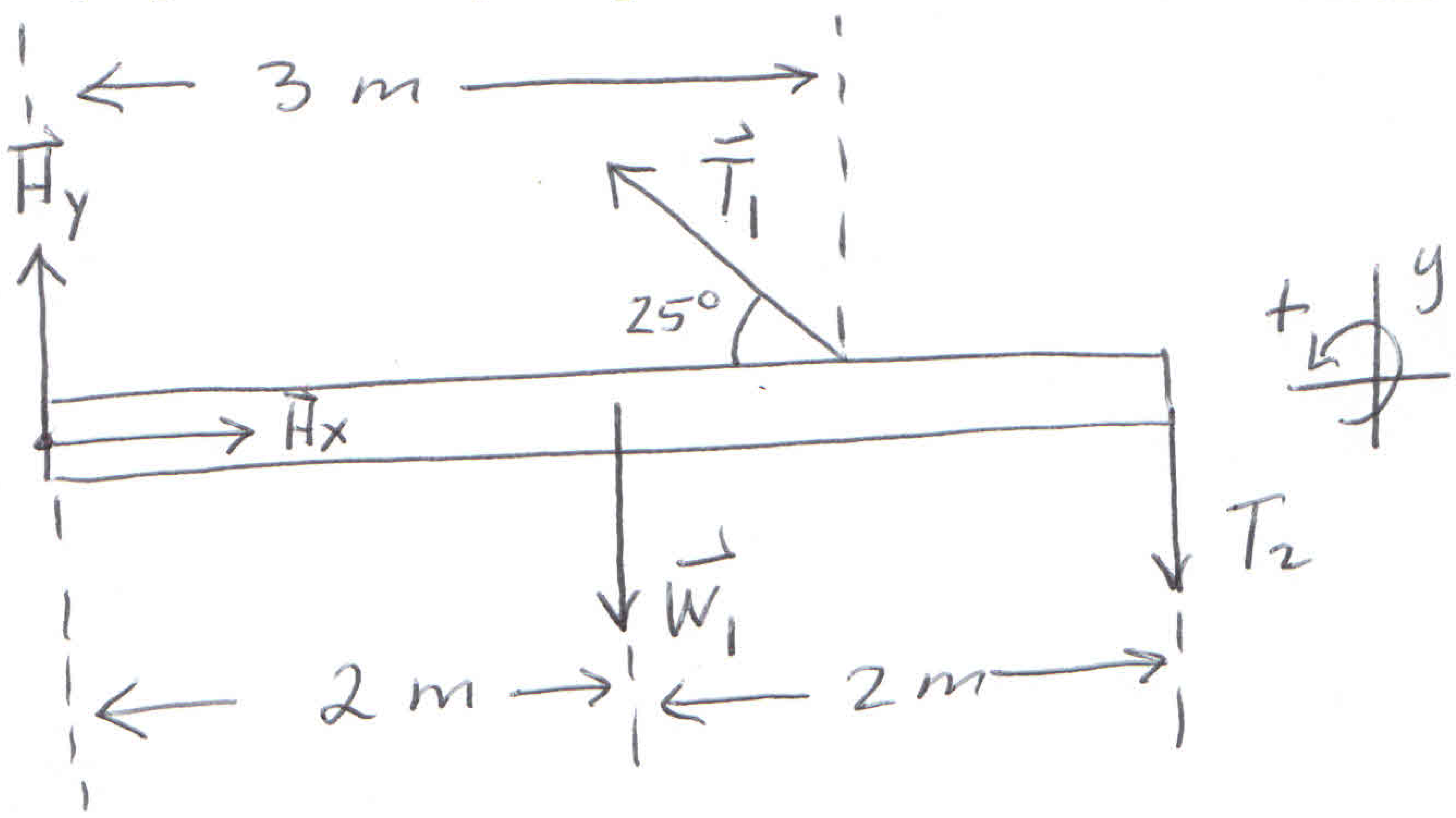
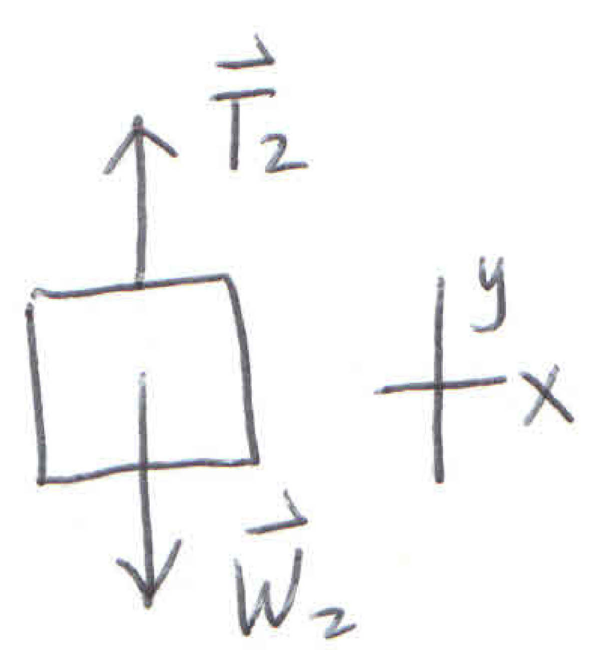
28 pts **14.** A uniform 1600 N beam of length 4.0 m is hinged at one end to the wall and held on the other end by a rope attached to the wall as shown below. A 700 N block is attached to the end of the beam by a second rope.



8 pts **A.** Draw proper Free Body Diagrams for the beam and the block.



5 forces @ ½ each = (2.5)
3 dimensions @ ½ = (1.5)
1 angle @ ½ = (0.5)
1 axis with rotation = (+1)
isolated = (+0.5)
6 pts



2 forces @ ½ each = (+1)
1 axis @ ½ = (+0.5)
isolated = (+0.5)
2 pts

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3 pts **B.** Find the tension in the rope holding the block.

(+1) $\sum F_y = m_2 a_y = 0$

$T_2 - W_2 = 0$

(+1) $T_2 = W_2$

$T_2 = \boxed{700N}$

(+1)# (+1) units

6 pts **C.** Find the tension in the rope attached to the wall.

(+1) $\sum \tau_H = 0$

$-W_1(2m) + T_1 \sin(25^\circ)(3m) - T_2(4m) = 0$

(+1) (+1) (+1)

$T_1 = \frac{W_1(2m) + T_2(4m)}{(3m)\sin(25^\circ)}$

$T_1 \cong \frac{(1600N)(2m) + (700N)(4m)}{(3m)\sin(25^\circ)}$

$T_1 \cong \boxed{4{,}732 N}$ (+1)# (+1) units

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11 pts **D.** Find the magnitude and direction of the force applied by the hinge upon the beam?

(+1) $\Sigma F_x = 0$ (+1) $\Sigma F_y = 0$

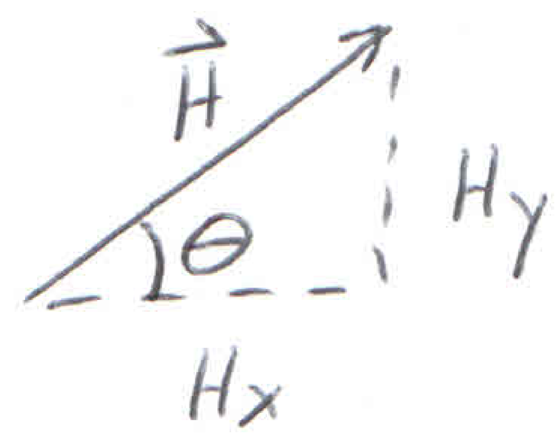
(+1) $H_x - T_1 \cos(25°) = 0$ (+1) $H_y + T_1 \sin(25°) - W_1 - T_2 = 0$

$H_x = T_1 \cos(25°)$ $H_y = W_1 + T_2 - T_1 \sin(25°)$

$H_x \cong (4{,}732N)\cos(25°)$ $H_y = 1600N + 700N - (4{,}732N)\sin(25°)$

(+1) $H_x \cong 4{,}289N$ (+1) $H_y \cong 300N$

(+1) $H = \sqrt{H_x^2 + H_y^2}$



$H \cong \sqrt{(4{,}289N)^2 + (300N)^2} \cong$ **4,300 N** ← (+1) #, (+1) units

$\theta = \tan^{-1}\left(\frac{H_y}{H_x}\right) \cong$ **4.00°** — # (+1)

(+1)

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BONUS PROBLEMS

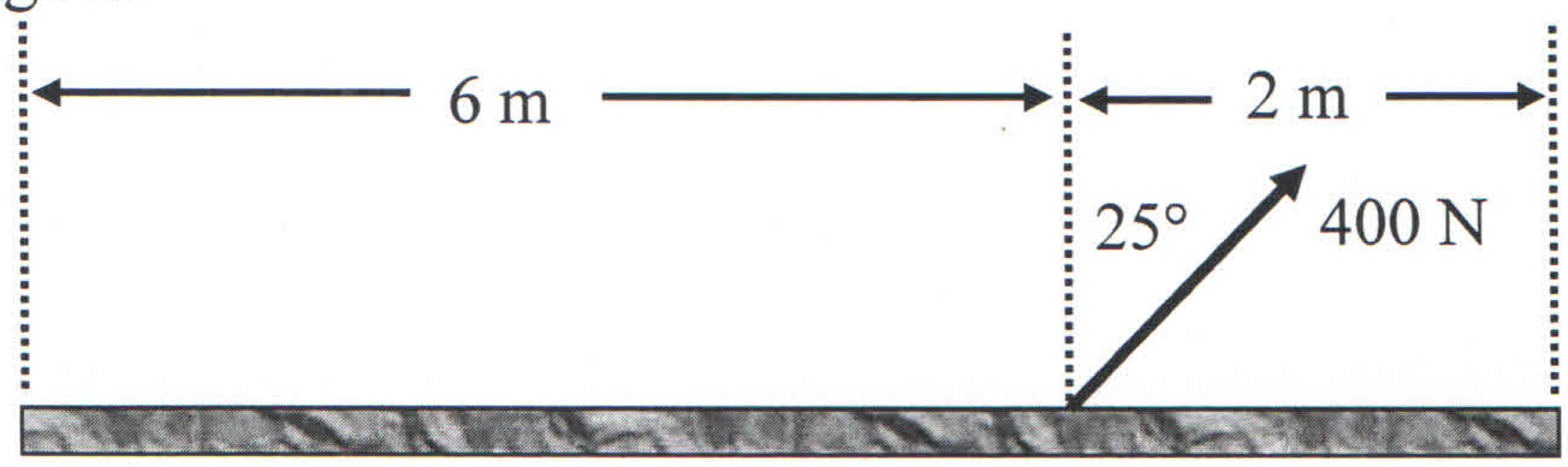
4 pts **1.** What is the condition necessary for an object to float in a fluid?

Density of object must be less than or equal to the density of the fluid.

Don't count off if they only say less than!!

They can write in symbols $\rho_o \leq \rho_f$

2. Calculate the magnitude of the torque produced by the 400 N force applied to the bar as shown below for an axis perpendicular to the page at:



4 pts **A.** the left end of the bar

$$|\vec{\tau}| = (6m)(400N)\cos(25°) \cong \boxed{2,175\ Nm}$$

(+1) (+1) (+1)# (+1) units

4 pts **B.** the right end of the bar

$$|\vec{\tau}| = (2m)(400N)\cos(25°) \cong \boxed{725\ Nm}$$

(+1) (+1) (+1)# (+1) units

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4 pts **3.** Give the value of 1.0 atmospheres in the following units:

2pts **A.** bars

1.013 bar => accept 1.01

2pts **B.** torr

760 torr

2 pts 4. An object has a density of 1250 kg/m^3. What is its specific density?

$$\frac{1250\ kg/m^3}{1000\ kg/m^3} = 1.25$$